with the restriction of a supply power source, the reduction of power consumption during measurement has been demanded.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 5839527

Summary

Technical Problem

[0005] As the detection method by the GSR sensor, there exist two methods of rising pulse detection and falling pulse detection. In rising pulse detection, the magnetic field sensitivity is about 2.5 times as high as that of falling pulse detection, which shortens pulse time and reduces power consumption. However, the linearity is about 1 to 2% and is inferior to that of falling pulse detection of 0.5% or lower.

The invention aims at making the most use of advantages of rising pulse detection while making its linearity 0.5% or lower.

[0006] A coil output voltage (hereinafter, referred to as a coil voltage) of the GSR sensor includes two kinds of voltages of an induced voltage dependent on a pulse current (referred to as an "a voltage") and a voltage dependent on an external magnetic field (referred to as a "b voltage"). In comparison between rising pulse detection and falling pulse detection, two voltage peaks are more adjacent to

each other in the case of falling pulse detection, and the influence by a pulse current is larger. Moreover, the MI effect changes the impedance of magnetic wires by a magnetic field. As a result, the "a voltage" dependent on a pulse current is also influenced by the magnetic field, and may not be canceled easily. That is, if the "a voltage" is not influenced by a magnetic field, the "a voltage" may be measured with H = 0G, and a net b voltage may be thus detected by cancelling the "a voltage".

[0007] The investigation for removing an induced voltage dependent on a pulse current from a coil voltage found by rising pulse detection has been performed for 20 years. However, it remains an unsolved difficult problem.

Solution to Problem

[0008] The inventors found that if two magnetic wires are arranged in one coil and a pulse current is applied in opposite directions, a coil induced voltage of rising pulse detection becomes 0 when H = 0 G (Fig. 7). It is recognized that if an electric current is applied in opposite directions in the case where a magnetic field H exists, the coil voltage is not changed and only the "b voltage" is detected (Fig. 8). That is, the "a voltage" is apparently disappeared.

Furthermore, in the measurement of the "b voltage" while changing a magnetic field, they found that the voltage is

element) 1 includes, on a substrate 10, two magnetic wires (21 and 22), one coil 3 wound around the two magnetic wires, two electrodes (24 and 25) for wire energization, two electrodes (34 and 35) for coil voltage detection, a connection part between the magnetic wires and the wire energization electrodes, and a connection part between the coil and the coil voltage detection electrodes. Moreover, the element 1 includes a means 23 for applying a pulse current to the two magnetic wires (21 and 22) in opposite directions. Then, the element 1 further includes a circuit 5 for detecting a coil voltage occurred when a pulse current is applied and a means for converting a coil voltage into an external magnetic field. The external magnetic field H and the coil voltage Vs are expressed by the mathematical relation of the above-described expression (1).

[0024] < Structure of element >

The structure of the element 1 is as illustrated in Fig. 1 and Fig. 2.

The size of the element 1 is 0.07 mm to 0.4 mm in width and 0.25 mm to 1 mm in length, which is the size of the substrate 1. In the center part of the element 1, the substrate 10 has a groove of 20 to 60 μm in width and 2 to 20 μm in depth so that the two magnetic wires (21 and 22) are aligned and disposed in parallel to each other. The two

[0030] < Magnetic wire and coil wiring structure >

In the wiring structure of the magnetic wire 2, the wire input electrode (+) 24 is connected to the upper part of the magnetic wire 21, and the lower part of the magnetic wire 21 is connected to the lower part of the magnetic wire 22 through the wire connection part 23, as illustrated in Fig. 1. The upper part of the magnetic wire 22 is connected to the wire output electrode (−) 25. This wire connection part 23 enables a downward flow of a pulse current from the upper part to the lower part in the magnetic wire 21, and an upward flow of a pulse current from the lower part to the upper part (in the opposite direction from the direction in the magnetic wire 21) in the magnetic wire 22.

[0031] In the wiring structure of the coil 3, the coil output electrode (+) 34 is connected to the lower end part of the coil 3, and the upper end part of the coil 3 is connected to a coil ground electrode (−) 35, as illustrated in Fig. 1.

[0032] < Electronic circuit >

An electronic circuit 5 includes a pulse generating circuit 51 for generating a pulse current, an input circuit 53 for inputting a coil voltage, a pulse compliant buffer circuit 54, the sample hold circuit with an electronic switch 56 for detecting a peak voltage of an output waveform of a coil voltage and a capacitor with a capacitance of 4 to 100

the capacitor capacitance is preferably 4 to 8 pF.

In the coil output, the sensitivity is 50 mV/G to 3 V/G in the measurement range of 3 to 100G with a sin wave output, as illustrated in Fig. 6. The linearity is 0.3% or lower.

[0036] < Example >

Fig. 1 illustrates a plane view of the GSR sensor element according to the example. Fig. 2 illustrates a section view thereof. Fig. 5 illustrates an electronic circuit. The GSR sensor of the invention includes the GSR sensor element 1 having the two magnetic wires (21 and 22), the one coil 3 wound around the two magnetic wires, the two electrodes (24 and 25) for wire energization, and the electrodes (34 and 35) for coil voltage detection, the means for applying a pulse current to the magnetic wire 2, the circuit for detecting a coil voltage occurred when the pulse current is applied, and the means for converting a coil voltage into an external magnetic field H. The external magnetic field H and the coil voltage are expressed in the mathematical relation shown in the expression (1).

[0037] The size of the element 1 is 0.12 mm in length and 0.20 mm in width. The groove 11 on the substrate 10 is 40 μm in width and 8 μm in depth. The wire interval is 3 μm.

[0038] The magnetic wire (21 and 22) is formed of a CoFeSiB amorphous alloy coated with glass of 10 μm in